DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
FY2005 STTR Proposal Submission

DARPA's charter is to help maintain U.S. technological superiority over, and to prevent technological surprise by, its potential adversaries. Thus, the DARPA goal is to pursue as many highly imaginative and innovative research ideas and concepts with potential military and dual-use applicability as the budget and other factors will allow.

DARPA has identified technical topics to which small businesses may respond in the fiscal year (FY) 2005 STTR solicitation. Please note that these topics are UNCLASSIFIED and only UNCLASSIFIED proposals will be entertained. Although they are unclassified, the subject matter may be considered to be a "critical technology." If you plan to employ NON-U.S. Citizens in the performance of a DARPA STTR contract, please inform the Contracting Officer who is negotiating your contract. These are the only topics for which proposals will be accepted at this time. A list of the topics currently eligible for proposal submission is included followed by full topic descriptions. The topics originated from DARPA technical program managers and are directly linked to their core research and development programs.

ALL PROPOSAL SUBMISSIONS TO DARPA MUST BE SUBMITTED ELECTRONICALLY THRU WWW.DODSBIR.NET.

It is mandatory that the complete proposal submission -- DoD Proposal Cover Sheet, **ENTIRE** Technical Proposal with any appendices, Cost Proposal, and the Company Commercialization Report -- be submitted electronically through the DoD SBIR website at http://www.dodsbir.net/submission. Each of these documents is to be submitted separately through the website. Your complete proposal **must** be submitted via the submissions site on or before the **6:00am EST, 15 April 2005 deadline.** A checklist has been prepared to assist small business activities in responding to DARPA topics. If you have any questions or problems with electronic submission, contact the DoD SBIR Help Desk at 1-866-724-7457 (8am to 5pm EST).

Acceptable Format for On-Line Submission: All technical proposal files must be in Portable Document Format (PDF) for evaluation purposes. The Technical Proposal should include all graphics and attachments but should not include the Cover Sheet or Company Commercialization Report (as these items are completed separately). Complete the cost proposal in the format shown in the Cost Breakdown Guidance, either using the on-line cost proposal form on the DoD Electronic Submission Web Site or include it as the last page of your technical proposal if not using the Web Site's on-line cost proposal form.

Technical Proposals should conform to the limitations on margins and number of pages specified in the front section of this DoD solicitation. However, your cost proposal will only count as one page and your Cover Sheet will only count as two, no matter how they print out after being converted. Most proposals will be printed out on black and white printers so make sure all graphics are distinguishable in black and white. It is strongly encouraged that you perform a virus check on each submission to avoid complications or delays in submitting your Technical Proposal. To verify that your proposal has been received, click on the "Check Upload" icon to view your proposal. Typically, your proposal will be uploaded within the hour. However, if your proposal does not appear after an hour, please contact the DoD Help Desk.

DARPA recommends that you complete your submission early, as computer traffic gets heavy near the solicitation closing and slows down the system. **Do not wait until the last minute.** DARPA will not be responsible for proposals being denied due to servers being "down" or inaccessible. Please assure that your e-mail address listed in your proposal is current and accurate. By the end of April, you will receive an e-mail acknowledging receipt of your proposal.

PLEASE DO NOT ENCRYPT OR PASSWORD PROTECT TECHNICAL PROPOSAL

HELPFUL HINTS:

1. Consider the file size of the technical proposal to allow sufficient time for uploading.
2. Perform a virus check.
3. Signature is no longer required at the time of submission.
4. Submit a new/updated Company Commercialization Report.

5. Please call the Toll Free SBIR Help Desk if you have submission problems: 866-724-7457
6. DARPA will not accept proposal submissions by electronic facsimile (fax) or email.

Additional DARPA requirements:

- DARPA Phase I awards will be Firm Fixed Price contracts.

- Phase I proposals **shall not exceed $99,000,** and may range from 8 to 12 months in duration. Phase I contracts cannot be extended.

- DARPA Phase II proposals must be invited by the respective Phase I DARPA Program Manager (with the exception of Fast Track Phase II proposals – see Section 4.5 of this solicitation). Phase 2 invitations will be based on the technical results reflected in the Phase I draft and/or final report as evaluated by the DARPA Program Manager utilizing the criteria in Section 4.3. DARPA Phase II proposals must be structured as follows: the first 10-12 months (base effort) should be approximately $375,000; the second 10-12 months of incremental funding should also be approximately $375,000. The entire Phase II effort should generally not exceed $750,000.

Prior to receiving a contract award, the small business **MUST** be registered in the Centralized Contractor Registration (CCR) Program. You may obtain registration information by calling 1-888-227-2423 or Internet: http://www.ccr.gov.

The responsibility for implementing DARPA's Small Business Technology Transfer (STTR) Program rests with the Contract Management Office. The DARPA SBIR/STTR Program Manager is Connie Jacobs, see address below. DARPA invites small businesses, in cooperation with a researcher from a university, an eligible contractor-operated federally funded research and development center (FFRDC), or a non-profit research institution, to submit proposals thru the DoD website www.dodsbir.net/submission.

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
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STTR proposals submitted to DARPA will be processed by DARPA and distributed to the appropriate technical office for evaluation and action.

DARPA selects proposals for funding based on technical merit and the evaluation criteria contained in this solicitation document. DARPA gives evaluation criterion a., "The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution" (refer to section 4.2 Evaluation Criteria - Phase I), twice the weight of the other two evaluation criteria. **TRANSITION OF THE PROPOSED EFFORT IS VERY, VERY IMPORTANT. THE SMALL BUSINESS SHOULD INCLUDE THEIR TRANSITION VISION IN THEIR COMMERCIALIZATION STRATEGY. THE SMALL BUSINESS MUST UNDERSTAND THE END USE OF THEIR EFFORT AND THE END USER, i.e., ARMY, NAVY, AF, SOCOM, ETC.**

As funding is limited, DARPA reserves the right to select and fund only those proposals considered to be superior in overall technical quality and highly relevant to the DARPA mission. As a result, DARPA may fund more than one proposal in a specific topic area if the technical quality of the proposal(s) is deemed superior, or it may not fund any proposals in a topic area. Each proposal submitted to DARPA must have a topic number and must be responsive to only one topic.

- Cost proposals will be considered to be binding for 180 days from closing date of solicitation.

- **Successful offerors will be expected to begin work no later than 30 days after contract award.**

- For planning purposes, the contract award process is normally completed with 45 to 60 days from issuance of the selection notification letter to Phase I offerors.

DARPA FY2005 Phase I STTR
Checklist

Page Numbering

Number all pages of your proposal consecutively ______
Total for each proposal is 25 pages inclusive of cost proposal and resumes.
Beyond the 25 page limit do not forward appendices, attachments and/or additional references.
Company Commercialization Report **IS NOT** included in the page count

Proposal Format

b. Cover Sheet, Technical and Cost proposals, and Company Commercialization Report MUST be submitted electronically ______

c. Identification and Significance of Problem or Opportunity ______

d. Phase I Technical Objectives ______

e. Phase I Work Plan ______

f. Related Work ______

g. Relationship with Future Research and/or Development ______

h. Commercialization Strategy ______

i. Key Personnel, Resumes ______

j. Facilities/Equipment ______

k. Consultants ______

l. Prior, Current, or Pending Support ______

m. Cost Proposal ______

n. Company Commercialization ______

o. Agreement between the Small Business and Research Institution ______

SUBJECT/WORD INDEX TO THE DARPA FY2005 STTR TOPICS

Subject/Keyword **Topic Number**

3-D Modeling 003
3D Reconstruction 003

Broadband 004

Chalcogenide Fibers 008
Command Control 002
Computer Vision 003

Decision-Supports Systems 002
Distributed Sensors 009

Electronic Warfare 007

Fiber Optics 007
Fluorozirconate Fibers 008

Group Decision-Support Systems 002

High-Speed Detectors 005
High-Speed Detector-Signal Processor 005
High-Speed Imaging 005
Human/Computer Interfaces 002

Image Understanding 003
Imaging Sensors 004
Infrared Countermeasures 008

Matched Filtering 006
MAV 003
Micro Air Vehicles 003
Micro-Optical Components 004
Microwave Photonics 007
Mid Infrared Lasers 008
Mixed-Initiative Software 002

Nano-Structured Rare Earth Doped Composites 008

Optical Imaging Sensors 009
Optical Switching 006

Photo Detectors 007
Photodiodes 007

Phrase Translation 001

Radar 007
Raman Amplification 008
Range Measurement 003
RF Photonics 006
Room-Temperature Infrared 005

SFM 003
Shape from Motion 003
Signal Processing 009
Silica Composite Fibers 008
Sparse Tapped Delay Lines 006
Speech Translation 001

Tapped Delay Lines 006

UAV 003

Unmanned Air Vehicles 003

Video Modeling 003

Wide Angle Scanners 004
Wideband Beam Forming 006
Wireless Networks 009

DARPA STTR 2005 Topic Index

ST051-001	Portable Bidirectional Speech Translator for Strategic Languages
ST051-002	Human-Machine Interfaces for Coordination Decision Support in Tactical Settings
ST051-003	3D Model Construction from a Micro Air Vehicle
ST051-004	Wide Field of View Electronically Stearable Imaging Sensors
ST051-005	High Speed Room Temperature Infrared Imaging
ST051-006	Reconfigurable, Sparse Optical Tapped Delay Lines for Matched Filtering
ST051-007	High Current Photodetector
ST051-008	Mid Infrared Fiber Lasers
ST051-009	Expendable Local Area Sensors in a Tactically Interconnected Cluster (ELASTIC)

ST051-001 TITLE: Portable Bidirectional Speech Translator for Strategic Languages

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: To produce prototypes and evaluation of a portable speech translator that can permit bidirectional information exchange between an English speaker and an untrained speaker of a different language.

DESCRIPTION: One-way phrase translation devices such as the Phraselator have proven successful in several contexts. These devices permit hands-free speech translation: a user can speak an English phrase into the device, which will find a matching phrase in its memory and output the corresponding phrase in a foreign language. One-way phrase translation allows English speakers to give commands or information to speakers of other languages, and can be supplemented with gestures or pictures to provide limited help in information exchange. One way translators are in use in force protection, asset protection, and peacekeeping applications.

It is likely that bidirectional speech translation can provide more effective information exchange, extending our ability to communicate with people around the world. A bidirectional translator would translate spoken English into a spoken foreign language such as Arabic, and would translate spoken Arabic into spoken English. An English speaker could thus ask questions and understand the answers.

Bidirectional translators need not permit free, unstructured conversation. It is possible that a translator will translate only restricted sets of phrases in each language, as long as the phrase set is flexible enough to permit information exchange. More flexibly, the translator may permit unrestricted utterances within a limited domain of discourse or a limited application. Translators produced under this program should select a domain restriction strategy that makes them effective in information exchange with an untrained monolingual speaker of a foreign language.

Most crucial to enhancing the utility of speech translation is a rapid prototyping capability. Building a bidirectional speech translator is a labor-intensive activity: it may take months or years to build a bidirectional translator between English and a new language. Much of this time is spent in data collection and on the construction of acoustic models, grammars, and other descriptions of the new language. Because of the dispersed nature of the threats to the United States, we may be called upon to communicate with people anywhere in the world on short notice. Translators produced under this program should include a rapid prototyping capability for new languages.

PHASE I: Prepare the design of a portable bidirectional speech translator for languages of strategic interest to the Department of Defense (DoD). The hardware platform should be sufficiently rugged and portable for field use within the military. The translator should permit information exchange between an English speaker and an untrained monolingual speaker of a foreign language. The information exchange may be in a limited domain such as force protection or medical interview, or may be in an unrestricted domain of discourse. Prepare a plan for implementing translators between English and two different languages, and for evaluating their effectiveness in field use. Prepare an estimate of the time needed to implement a translator for a new language.

PHASE II: Produce five copies of a prototype bidirectional speech translator that permits information exchange between an English speaker and monolingual speakers of a foreign language. Evaluate the effectiveness of the speech translator in field use. Prepare a detailed plan and cost estimate for implementing a translator for a new language. Estimate the cost of a single translator for an already implemented language.

PHASE III Dual Use Applications: In addition to their use in DoD applications, speech translators would be of interest to a large variety of users, such as tourists, international businesses, medical, law enforcement, and immigration personnel.

REFERENCES:
1. VoxTec; www.phraselator.com.

2. Precoda, K., Franco, H., Dost, A., Frandsen, M., Fry, J., Kathol, A., Richey, C., Riehemann, S. Vergyri, D., Zheng, J., Culy, C. "Limited-Domain Speech-to-Speech Translation between English and Pashto"; HLT/NAACL 2004 Demonstrations, Boston, MA, May 2004, pp. 9-12.
3. Fu-Hua Liu, et al, "Applications of Language Modeling in Speech-to-Speech Translation"; International Journal of Speech Technology, Vol. 7, 221-229, 2004.
4. Liang Gu, Yuqing Gao, "On Feature Selection in Maximum Entropy Approach to Statistical Concept-based Speech-to-Speech Translation"; International Workshop on Spoken Language Translation, Kyoto, Japan, September, 2004.
5. Bowen Zhou, et al, "A HAND-HELD SPEECH-TO-SPEECH TRANSLATION SYSTEM"; IEEE Automatic Speech Recognition and Understanding Workshop, St Thomas, December, 2004.
6. S. Narayanan, et al; The Transonics Spoken Dialogue Translator: An aid for English-Persian Doctor-Patient interviews; AAAI Fall 2004 symposium.

KEYWORDS: Speech Translation, Phrase Translation

ST051-002 TITLE: <u>Human-Machine Interfaces for Coordination Decision Support in Tactical Settings</u>

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Traditional approaches to developing interactive systems for mission support have proven virtually unusable for mobile, tactical command-and-control situations. Achieving the objective of the future-force warrior requires the development of human-machine interfaces that optimize the focus of user attention, enabling war fighters to perceive and interact with their environment well beyond the limits of current technologies. DARPA is seeking research to develop more natural interactive concepts that address the interaction requirements of mobile, automated coordination-support systems. This emerging decision-support technology, called coordination managers (or COORDINATORs), automates coordination between human units in the field. COORDINATORS facilitate the management of mission-critical resources in highly dynamic, stressful environments and would benefit from advances in the ability to filter, organize and present information originating from a variety of sources, in real time, and in a way that takes into account the information needs and requirements of individual users.

DESCRIPTION: The DARPA COORDINATORs program (BAA 04-29) will transform decision-support technology for tactical fielded units. Coordination managers will assist fielded soldiers by helping them to adapt their plans online in response to change from multiple sources (e.g., the environment, command, friction of war, the enemy, etc.). In response to change, the systems will make adjustments to task timings and task assignments, and will select from preplanned contingencies. New research in interaction models, user-interface paradigms that directly support online mission-critical planning applications and new techniques for optimizing the focus of user attention must be performed in order for this technology to realize its full potential. We are seeking to combine basic research that identifies and addresses fundamental human limitations in decision-making under stressful conditions together with technologies that are designed to support the management of teams working together in rapidly evolving circumstances.

Interactions between the coordination system and the human user during these processes include, but are not limited to: (1) the system producing a potentially large list of response options whose representation is complex (e.g., containing plan fragments and information about goals that are impacted by the option/change) and asking the human to choose from the list of options, (2) the system asking for input about a particular response option (e.g., change the timing, accept assignment, delegate, etc.) where the option may be similarly complex to describe, (3) the system informing the human of some change that has occurred or a decision that it made autonomously, (4) the system needing to display portions of complex mission structures and have the human provide direction, (5) the system asking the human when the human will be able to respond to a more complex issue (if a response cannot be had now), (6) the human being able to indicate to the system that some other course of action is desired and to describe said course of action.

Because these technologies are for tactical deployment, issues like temporal response and information overload should be considered. The envisioned human-machine interface technology should also take into account both the real-world battlefield environment and the nature of human cognition and information-processing capabilities, particularly in naturalistic decision-making domains. It should consider focus-of-attention issues and provide the ability to support individual user preferences, as well as their unique tasks, resources, obligations, and constraints. User interaction capabilities should be sensitive to the skill and knowledge expertise of the user and the complexity of the activity. It should also generalize across a spectrum of information-processing systems, e.g. from small mobile terminals, to tablets and potentially to fixed workstations. Technology development should be based upon an understanding of how best to use the senses by which humans perceive their environment and how they can affect it.

Relevant research areas include but are not limited to: mobile rendering technologies, natural language, agent technology, multimodal interfaces, natural language annotations, speech and pen gesturing, and speech recognition. Candidate research issues to consider include but are not limited to: (a) analysis, selection, and development of multiple modalities for human-machine interaction that efficiently augment human cognitive performance; (b) optimization of user interface modality to minimize cognitive overload particularly during intense, time-critical decision-making processes (e.g. if visual is too complex, use auditory or haptic); (c) development of key user interface metrics within a mobile command and control environment where metrics may define/describe (1) improvements in human information processing (i.e. degree and/or speed of situation understanding, improvements to cognitive overload, or removal of uncertainty), (2) precision and accuracy of interface mechanism versus speed and response time, and (3) quantifiable improvements in operator performance.

PHASE I: Conduct initial research and develop an initial functional design of an interaction system that enables fielded human units to work effectively with the mobile coordination system. Produce at least one detailed software design (include hardware as appropriate). Establish the ability of the interface design to facilitate coordination and decision-making in tactical battlefield environments by walking through its use on a hypothetical tactical team coordination scenario. Identify key metrics to quantify the expected benefits of the interface (see list above).

PHASE II: Produce a fully functional prototype mobile interactive coordination interface technology. Engage in a spiral research-and-development process to experiment with the prototype then clarify the research issues, conduct additional research, and refine the prototype. For Phase II the prototype may either be coupled with the actual coordination manager reasoning technology or be developed with scripted inputs/outputs.

PHASE III Dual Use Applications: The envisioned advances in interface technology could be used in a broad range of military and civilian applications that involve time-critical decision-making under stressful conditions. Examples include emergency response management, law enforcement command-and-control systems, and coordination of mobile industrial or commercial workers.

REFERENCES:
1. DARPA Solicitation 04-29, ref. http://www.darpa.mil/baa/04-29.html.
2. Army Science Board, 2002 Ad Hoc Study; Human-Robot Interface Issues; September 2002.
3. Card, S. The Psychology of Human-Computer Interaction, Erlbaum, 1983.
4. Mulgund, S., Stokes, J., Turieo, M., and Devine, M.; Human/Machine Interface Modalities for Soldier Systems Technologies TIAX LLC CAMBRIDGE MA 2002.

KEYWORDS: Human/Computer Interfaces; Decision-Supports Systems; Group Decision-Support Systems; Mixed-Initiative Software; Command Control.

ST051-003 TITLE: <u>3D Model Construction from a Micro Air Vehicle</u>

TECHNOLOGY AREAS: Air Platform, Information Systems, Sensors, Electronics, Battlespace

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and demonstrate a system that supports navigation and reconnaissance from a Micro Air Vehicle (MAV) by automatically computing the pose of the aircraft and the 3D structure of the surrounding environment from video collected in flight.

DESCRIPTION: Two of the critical capabilities for making small- and micro-air vehicles (SMAV) autonomous and useful are the precise estimation of the SMAV states (pose and position) and 3D mapping of its surrounding environment. In theory, 3D vision can estimate from the video of an on-board camera the 3D structure of the surrounding environment as well as the vehicle state (pose and position). This problem has been studied extensively in the field of computer vision as the structure from motion (SFM) problem. For its on-board use for (SMAV), however, there are three critical differences that make the SFM solution far more difficult than typical off-line SFM applications, such as scene modeling from video and motion recovery for image-based rendering. First, the input videos are of lower quality. On-board cameras tend to have lower resolution, poor contrast, and significant noise. Second, unlike the computer graphics applications, videos are not taken by design, and therefore they include large motion or motion blur due to fast aircraft motions and rotations, or degenerate motions that make some solution methods singular. Third, the process must give the best solution using the images up to that point in time; unlike off-line applications; future; images cannot be used. The key to successful use of SFM for SMAV control is to make the SFM process robust to these difficulties. Doing so will require innovative research to advance technology for all key components, including feature extraction, feature tracking, and robust structure estimation.

If successful, the result will enable SMAVs to navigate in tightly constrained environments, such as indoors, underground, and in forests. Additionally, 3D models produced by SMAVs have enormous value to support a wide range of military applications, including mission planning, hostage rescue, prediction of weapon effects, and sensor placement.

PHASE I: Prepare a feasibility study of an automatic SFM solution suitable for a SMAV. Characterize the range and accuracies achievable, and design an algorithmic approach to achieve it. Determine the appropriate metrics for measuring the performance of components to be developed in Phase II, and the performance levels that would have to be achieved.

PHASE II: Research, develop and demonstrate all components of the approach, measuring performance on the key metrics identified in Phase I. Assemble the components into an integrated prototype system and demonstrate the performance using live video from a SMAV. Prepare a final report documenting the results of both component and system level evaluations.

PHASE III Dual Use Applications: Making feature detection, feature tracking and 3D reconstruction robust is the key to successful use of SFM not only for SMAV control but also for many other applications including visual surveillance, virtual meeting rooms, vehicle driver assistance, and robotic assistants to humans.

REFERENCES:
1. M. Pollefeys, L. Van Gool, M. Vergauwen, F. Verbiest, K. Cornelis, J.
Tops, R. Koch, “Visual modeling with a hand-held camera”, International Journal of Computer Vision 59(3), 207-232, 2004.
2. S. M. Ettinger, M. C. Nechyba, P. G. Ifju, and M. R. Waszak, “Vision-Guided Flight Stability and Control for Micro Air Vehicles,” Advanced Robotics, vol. 17, no. 3, pp. 617-40, November 2003.

KEYWORDS: Computer Vision, Video Modeling, Range Measurement, 3-D Modeling, Shape from Motion, SFM, Image Understanding, 3D Reconstruction, Micro Air Vehicles, MAV, Unmanned Air Vehicles, UAV

ST051-004 TITLE: Wide Field of View Electronically Stearable Imaging Sensors

TECHNOLOGY AREAS: Air Platform, Sensors, Electronics, Battlespace

OBJECTIVE: Design and develop micro-optical components, including unique electro-optical and micro-mechanical materials and devices, to flexibly direct the field of view of an imaging system over a wide acceptance angle. Optical micro-scanning components have the potential to replace bulky mechanical scanning systems based on gimbaled mounts, providing imaging systems where the field of view can be directed over wide azimuth and elevation angles. The micro-optical components shall address applications requiring spectral response from the short to long wave infrared.

DESCRIPTION: Wide field of view imaging systems fulfill a critical need in several applications, such as missile seekers, surveillance, and search and track. Currently, in these applications mechanical systems, such as gimbals, scan the optical field-of-view over wide angles, adding substantially to the size, weight and cost of optical sensors. In laser imaging systems, electro-optical approaches are currently being investigated to steer and precisely direct laser beams to designated point in the field of view. Similarly, micro-optical components can be employed to steer the acceptance angle of a broadband, passive optical imaging system. The micro-optical components leverage development of electro-optical materials and micro-mechanical optical techniques to steer broad band radiation over a wide field-of-view. Issues to be addressed include the range of steering angle, wavelength dispersion in the broad band components, and the precision in positioning of the field-of-view. The steering angle must cover a wide field-of-view of nominally +/- sixty (60) degrees in both azimuth and elevation, while maintaining near diffraction limited optical resolution defined by the optical aperture. This wide steering angle must also accommodate the spectral band required by application. Initially, steering over a particular spectral band, such as the short wave or mid wave infrared is acceptable, but ideally a broad spectral response over the entire band is desired. In addition, the field of view must be repositioned to an accuracy of a single pixel incremental field of view (IFOV). This is essential in precision track and applications for point target detection. The image quality is dependant upon several factors, but especially dispersion in the steering component. The dispersion is a function of the spectral bandwidth and steering angle. Novel materials may be considered to minimize dispersion, as well as digital processing for correction. Off axis distortions in classical imaging systems may also become a significant issue. Use of post detection processing to compensate these distortions is an acceptable solution as long as the post processing load is kept within bounds.

PHASE I: This phase will include an analysis of material and component requirements for broad band steering of the optical field of view. Components will be selected for specific wavelength bands from the short to long wave infrared, in addition to components potentially covering the complete wavelength band. Laboratory evaluations will be conducted to verify calculations of acceptable characteristics. The evaluation will include steering angle, performance relative to a diffraction limited aperture, beam positioning accuracy.

PHASE II: During this phase, beam steering micro-optical components will be optimized for performance in the spectral band selected, and integrated into a laboratory prototype. Imaging experiments will be performed to verify component specifications, and image quality.

PHASE III Dual Use Applications: The prototype camera design will be integrated into proof first article samples and distributed to users for evaluation. In addition to military users, applications include commercial cameras for surveillance, driving (especially night driving), and robotic vehicles.

REFERENCES:
1. P.F. McManamon and E.A. Watson, Non-mechanical Beam Steering for Passive Sensors; SPIE AeroSense Symposium, Orlando, Florida, 2001, Vol 4369.
2. Jeffrey J. Weinschenk, Russel C. Hardie, Kenneth J. Barnard, Scott R. Harris, Paul F. McManamon, Edward A. Watson, Broadband image steering using a liquid crystal device; SPIE AeroSense Symposium, Orlando, Florida, 2001, Vol 4369.

KEYWORDS: Imaging Sensors; Broadband, Wide Angle Scanners, Micro-Optical Components

ST051-005 TITLE: High Speed Room Temperature Infrared Imaging

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace

OBJECTIVE: Establish the basis for high speed room temperature infrared imaging through development of mathematical models, sensor designs and camera demonstrations employing short to long wave infrared arrays. Mathematical models will establish relationships between the fundamental processes controlling the detection device and the detector-signal processor interface when responding to high speed events. These must be corroborated with laboratory evaluations of detector and signal processor designs addressing rapid image acquisition at frame rates in the range of ten to fifty Kilohertz (kHz). Figures of merit and fundamental limits of high speed detector and signal processor interface will also be established.

DESCRIPTION: Detection and identification of high speed events requires high performance arrays usually operating at cryogenic temperature. The high speed event may be tracking a high speed projectile, collection of imaging frames from moving platforms, or the capture of an image from a rapidly changing industrial process. In each of these applications, an understanding of the fundamental physical mechanisms underlying detector response establishes the basis to control and improve high speed imaging. This is especially critical in sensors operating at or near room temperature. The physical processes controlling room temperature infrared devices have been evaluated for sensitivity, but models and simulations of high speed detection and imaging are not generally available. The time response is a complex process controlled by fundamental mechanisms in the detector, signal processor and the interface between detector and signal processor. At room temperature, the properties controlling detector sensitivity and time response may be conflicting, and the optimum design space must be established. Also, the detector/signal processor interface has a dramatic influence on speed. Novel input schemes at the signal processor input may overcome physical limitations imposed at the detector, resulting in an optimized room temperature high speed imaging microsystem.

PHASE 1: The contractor will develop a three-dimensional model describing the physical mechanisms controlling the detector operating at room temperature with response time of 0.1 to 0.02 milliseconds. The model will include detector parameters controlling response speed, such as carrier lifetime, mobility and surface effects, and the detector-signal processor interface. The model will include the operation of the detector operating in narrow spectral bands, which may also be used for discrimination of high speed events. Models will be compared to laboratory device performance, and methodology developed to characterize high speed events. The contractor will select examples of high speed processes and establish figures of merit for the detector and focal plane signal processor.

PHASE 2: The contractor will design, fabricate and evaluate detector sub-arrays and signal processor input circuit test chips. The data from test array evaluation will be correlated to models developed in phase I. A design will be established for a high speed camera with a detector operating at room temperature, and camera specifications developed, with clear flow-down to the critical components and sub-systems controlling response speed.

PHASE III DUAL USE APPLICATIONS: The high speed camera design will be finalized and a laboratory prototype developed. An evaluation plan will be established with users to assess camera capability to capture high speed events, including sensitivity, speed and image quality. Metrics for the camera evaluation will be established, and experiments conducted to verify camera performance in an industrial process control environment.

DUAL USE POTENTIAL: Characterization of high speed events, especially with inexpensive room temperature devices, has significant military potential in detection of projectiles, artillery and motor launches. Commercial manufacturing processes are also characterized by recording of high speed events. Inexpensive room temperature devices will make process control systems available in a wide range of applications, where rapid changing events must be recorded. These include biological and medical applications, industrial processes, including failure analysis and reliability improvement.

REFERENCES:
1. Materials and Electronics for High-Speed and Infrared Detectors; Proceeding of SPIE: Volume 3794; July 19-20 and 23, 1999; Denver, Colorado

KEYWORDS: Room-Temperature Infrared: High-Speed Imaging; High-Speed Detectors; High-Speed Detector-Signal Processor

ST051-006 TITLE: <u>Reconfigurable, Sparse Optical Tapped Delay Lines for Matched Filtering</u>

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Weapons

OBJECTIVE: Develop a large (256 tap) optical tapped delay line with variable weights and variable delays for operation at 10 GHz.

DESCRIPTION: Matched filters for optical and microwave communication links have attracted considerable attention over the past 20 years. Sparse tapped delay lines have demonstrated significant improvement over conventional tapped delay lines. Recent broadband analog photonic link performance improvements have renewed the interest and activity in developing this technology. Increased bandwidths and reduced fiber optic link insertion loss/noise figure accompanied by increased dynamic range have created real insertion opportunities of advanced fiber optic signal distribution manifolds and radio frequency (RF) photonic signal processors into antenna-based communications, radar, navigation, and electronic warfare systems. The development of an affordable high-performance reconfigurable sparse delay line enables the solution of many tapped delay line signal processing problems of military interest. This topic addresses the need for developing low loss; scalable, tapped delay line modules that can meet the challenging loss and variable tap weight requirements. Scalability is required in terms of time resolution/precision and delay range to satisfy various military and commercial applications. Innovative photonic device/module/system research and development is solicited that addresses this critical need. Novel algorithms for optimizing tap weights and delays are required.

PHASE I: Propose a feasibility study to investigate, model, and perform critical experiments to build a reconfigurable, sparse tapped delay line for operation at 1.5 microns with carrier frequencies from 8 to 12 GHz. Develop and analyze algorithms for tap weight and delay adjustment to achieve optimum matched filter performance.

PHASE II: Develop a 256 tap prototype reconfigurable sparse tapped delay line and demonstrate optical performance at 1.5 microns with carrier frequencies from 8 to 12 GHz. Develop algorithms to adjust tap weights and delays in an efficient manner. Perform laboratory testing of modules and adaptive signal processors in experimental setups that demonstrates their utility in both military RF systems and commercial optical telecommunication systems.

PHASE III Dual Use Applications: The programmable reconfigurable tapped delay lines and signal processors will be transitioned to commercial production for dual use applications. The primary military use will be in radar, communication and electronic warfare antenna signal processing systems. Wideband applications including Electronic Countermeasures (ECM), radar signal simulators, tunable microwave filtering and phased-array beam steering are key military insertions for this technology. Targeting these applications, the optoelectronic modules will be deployed on space, airborne, ground and maritime military command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) platforms. Modest market sizes are projected for these military applications in comparison to size anticipated for the optical telecommunications industry. The optoelectronic reconfigurable tapped delay line filters modules will provide an affordable matched filter for applications such as extending the bit rate and range of multimode communications at 10 Gbit/s. The optical telecommunications industry has been in search of such a device. A successful development in terms of unit cost and performance, will lead to a large market in optical networking systems, a multi-billion dollar commercial market. Cost is critical in commercial networking applications and ultimately determines volumes and market size. Low cost manufacturing will be a focus throughout this development to ensure the commercial viability of this technology.

KEYWORDS: Matched Filtering, Tapped Delay Lines, Optical Switching, Wideband Beam Forming, RF Photonics and Sparse Tapped Delay Lines

ST051-007 TITLE: <u>High Current Photodetector</u>

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Weapons

OBJECTIVE: Development of a high current, high linearity photo detector with 10 to 100 GHz bandwidth.

DESCRIPTION: Recently there has been tremendous progress made in the current handling capacity of Gigahertz bandwidth photo detectors throughout the 1300 to 1550 mn spectral region. Small-signal compression currents above 100 and 50 mA have been achieved at 10 GHz and 50 GHz, respectively. This makes for the possibility of Radio Frequency (RF) output signals over 20 dBm (100mW) directly from photo detectors possible. The progress in 100 GHz devices has lagged and at present is limited to detectable currents below 5 mA. If output RF powers can exceed 20 dBm while at the same time preserve the phase and amplitude noise purity of the driving oscillator (either externally modulated or offset-phase-locked heterodyned lasers), the possibility of delivering spectrally-pure high power RF signals at remote locations becomes feasible. In addition, it is desirable to increase photocurrents as higher photocurrent leads to lower loss, improved dynamic range and lower noise figure in microwave photonic links. The challenge to delivering high photocurrents is the careful design of the photo detector internal structure to minimize the heat loading and temperature of the intrinsic layers. The use of novel semiconductor materials and structures can improve device performance and would be encouraged as well as the use of more traditional designs. The goal of this effort would be to design and fabricate a high-quantum-efficiency (> 0.7 A/W) high-current (> 100 mA) linear (OIP3 > +40 dBm) high bandwidth (> 10 GHz) photo detector in the 1300 to 1550 nm region that is capable of delivering the highest spectral purity, lowest noise, highest power RF signal from a photo detector while keeping the thermal loading of the structure to a minimum.

PHASE I: The proposed photo detector design will be analyzed and evaluated in detail. It would be desirable to demonstrate a proof of principle device with measurements and calculations to support how the design would yield the desired performance goals.

PHASE II: Development of additional photo detector prototypes with performance tests to access the validity of the calculations/model used in the Phase I design. Both on-wafer and packaged devices should be tested.

PHASE III Dual Use Applications: A prototype would be used in microwave receiver system demonstrations involving analog photonic links for both EW and radar applications. The prototype will enable higher RF performance (noise figure, dynamic range and bandwidth) to be achieved within these military applications.

REFERENCES:

1. K.J. Williams and R.D. Esman, Design Considerations for High-Current Photo detectors; IEEE Journal of Light wave Technology, Vol. 17, no. 8, p. 1443, 1999.
2. K.J. Williams, L.T. Nichols, and R.D. Esman; Photo detector Nonlinearity Limitations on a High-Dynamic Range 3 GHz Fiber Optic Link; IEEE Journal of Light wave Technology, Vol. 16, no. 2, p. 192, 1998.
3. K.J. Williams; Comparisons between dual-depletion-region and uni-traveling-carrier p-i-n photo detectors; IEE Proc.-Optoelectronic, Vol. 149, No. 4, p. 131, Aug 2002.

KEYWORDS: Photo Detectors, Photodiodes, Microwave Photonics, Radar, Electronic Warfare, Fiber Optics

ST051-008 TITLE: Mid Infrared Fiber Lasers

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace, Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Prepare a Phase I feasibility Study to develop Mid Infrared Fiber Lasers for infrared countermeasures (IRCM) that can be deployed on fixed wing/rotary wing manned and unmanned airborne platforms for defense against heat seeking missiles or man-portable air defense system (MANPADS).

DESCRIPTION: Airborne fixed wing/rotary wing manned or unmanned platforms are vulnerable to shoulder launched heat seeking missiles or MANPADS in tactical battlefield or urban military operations. The IRCM systems currently under development are based on diode pumped solid state lasers pumping optical parametric oscillators to generate mid infrared wavelengths, through frequency conversion, in the 3 to 5 micrometer spectral region through frequency conversion. These IRCM systems require accurate optical alignment and stability combined with tracking and pointing systems that are complex, bulky and expensive. Mid infrared fiber lasers in the 3 to 5 micrometers spectral region without a need for frequency conversion may provide an attractive alternative to the IRCM systems under development. Fiber lasers have inherently good beam quality, require no optical alignments and large surface to volume ratio enables efficient thermal management. The wall-plug efficiencies of fiber lasers in excess of 20 percent are higher than diode pumped solid state lasers. They are also robust and can be packaged in a compact footprint. Laser radiation in the mid infrared can be multiplexed to different locations in the platforms without the need for robust optical alignment. Mid infrared fiber lasers can be developed through Raman amplification in chalcogenide based fibers or fluorozirconate fibers, or as fiber lasers using nano-structured rare-earth-doped halides as gain media in silica matrix. Sol-gel processing methods proven to make inexpensive glass preforms for the telecom industry can be used to make nano-composite preforms and processed with conventional draw tower methods to make optical fibers. This topic seeks to develop mid infrared fiber lasers with tens of watts output at more than three lines in the 3 to 5 micrometer spectral range. In addition, mid infrared fiber lasers can be used for chemical and biological sensing.

PHASE I: Prepare a feasibility study of mid infrared fiber lasers in the 3 to 5 micrometer spectral regions using either Raman amplification in chalcogenide or fluorozirconate fibers or as fiber lasers based on nano-structured rare-earth-doped halides as gain media in silica matrix. Formal design concepts to generate tens of watts at three or more wavelengths in the 3 to 5 micrometer spectral regions shall be developed. As a part of the final report, plans for Phase II shall be proposed.

PHASE II: The designs from Phase I shall be finalized, in conjunction with specific airborne platforms. A critical deign review will be performed to generate tens of watts at more than three wavelengths in the 3 to 5 micrometer spectral regions and a breadboard laser system will be demonstrated.

PHASE III Dual Use Applications: Several prototype units of mid infrared lasers with tens of watts of output at more than three wavelengths in the 3 to 5 micrometer spectral region will be fabricated to test for robustness and reliability for qualification and deployment on airborne platforms. There are both military and commercial applications for mid infrared lasers in the 3 to 5 micrometer spectral regions including environmental sensing and medical applications.

REFERENCES:
1. Jas S. Sanghera and Ishwar D. Agarwal, Infrared Fiber Optics, CRC Press, 1998, ISBN: 0849324890.

KEYWORDS: Mid Infrared Lasers, Infrared Countermeasures, Raman Amplification, Chalcogenide and Fluorozirconate Fibers, Nano-Structured Rare Earth Doped Composites, and Silica Composite Fibers

ST051-009 TITLE: <u>Expendable Local Area Sensors in a Tactically Interconnected Cluster (ELASTIC)</u>

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Prepare a Phase I feasibility Study for research and development of Expendable Local Area Sensors in a Tactically Interconnected Cluster (ELASTIC) - a set of small, ballistically distributed optical imaging sensors that form an ad hoc wireless network, and optionally, a hierarchical network for aggregating and up-linking hi-bandwidth image and other sensor data directly to the personnel on the scene responsible for making tactical decisions. The sensor network reports back to a local node where the information is immediately used to guide tactical decisions.

DESCRIPTION: In many tactical situations, there is a critical need for a method of projecting situational awareness into high-risk or inaccessible locations. Examples include:

· A squad of soldiers preparing to move into a building, street, or other confined area where an ambush might be waiting.
· Establishing a "trip-wire" barrier or perimeter in areas not easily or safely accessible: roofs of buildings in urban areas, across inaccessible or dangerous terrain, etc.
· Leaving "sentinel" sensors in areas where it is not feasible or desirable to maintain a continuing human presence.

These tasks are usually preformed by humans at considerable risk. In some circumstances robots are used, but these are usually expensive solutions that are not always readily available. What is needed is an easily transported, always available method of obtaining critical situational awareness to help shape the tactical decisions of the people on the scene or front lines. One concept may be Expendable Local Area Sensors in a Tactically Interconnected Cluster (ELASTIC). The ELASTIC concept is a set of small, ballistically distributed sensors that form an ad hoc wireless network, and optionally, a hierarchical network for aggregating and up-linking hi-bandwidth image and other sensor data directly to the personnel on the scene responsible for making the tactical decisions. The sensor network reports back to a local node where the information is immediately used to guide tactical decisions. There will also be a lower-bandwidth down-link capability from the tactical operator back to the sensors to support multiple modes of operation-alert level (including hibernation), region of interest (ROI) selection, limited motion of sensor, etc. This requires the design of imaging systems using only simple molded plastic lenses that are nevertheless capable of quality imaging over a large volume; including a large depth-of-focus (DOF) and wide viewing angle. Simple signal processing at the other end of the up-link produces high-quality images from the sensor data. More elaborate processing can produce increased resolution ("Super-Resolution" or SR) for regions of interest (ROI) selected by the operator. This is a "digital zooming" capability. Multiple sensor modes are also possible, with some sensor units reporting sound, motion detection (optical, sonar or radar), vibration, etc. The ELASTIC concept envisions using wireless capabilities within the current state of the art for the networking of the sensors:

a. Peer-to-peer ad-hoc network capability would suffice for low-bandwidth sensor information and schemes for locating the distribution of the sensors in the target area. This capability would be two-way and would allow instructions to flow from the operator to the sensor net. Average power consumption on the order of several 100 nanowatt (nW) is easily achievable using current technology.

b. High bandwidth uplink-only capability for primarily image data sent from the sensors to the local operator. A transmit only capability for full motion video would require a power consumption of approximately 1 milliwatt (mW). This requirement can be reduced by compressing or otherwise reducing the data sent (for example, only sending the data in each frame which has changed from the previous frame), or by including a separate, non-sensing, unit which aggregates data from the local sensors and re-transmits it at higher power. It is possible that custom Complementary Metal Oxide Semiconductor (CMOS) imaging chips could perform the frame-differencing operation during readout.

PHASE I: Prepare a feasibility study ELASTIC concept: a.) Design suitable imaging systems, b.) Identify and evaluate capabilities of low-power wireless network technology, c.) Identify and model signal-processing requirements. Explore methods of spatially locating deployed sensor network.

PHASE II: The designs from Phase I shall be finalized for ELASTIC concept, in conjunction with imaging demonstration - fabricate and demonstrate image sensors and design, fabricate, and demonstrate wireless imagers capable of ballistic deployment in a benign operational environment.

PHASE III Dual Use Applications: Several prototype units of imaging sensors for ELASTIC concept will be fabricated and demonstrated in numerous tactical battlefield and urban military operations environment. There are both military and commercial applications for mid ELASTIC Concept. The technology is applicable to surveillance of critical infrastructure and reduces manned operations at perimeter surveillance of commercially vulnerable assets.

REFERENCES: None. This concept evolved from technical discussions with numerous technical experts in the area of miniaturized optical sensors that are networked.

KEYWORDS: Optical Imaging Sensors, Distributed Sensors, Wireless Networks, Signal Processing